PATENT SPECIFICATION

DRAWINGS ATTACHED

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COMPLETE SPECIFICATION

Thermoplastic resin article, a method and apparatus for producing such article

We, GUNMA KAGAKU KABUSHIKI KAISHA and NIPPON EKIKA SEIKEI KABUSHIKI KAISHA, Japanese corporate bodies, respectively of 10, 1-chome, Yuraku-cho, Chiyoda-ku, Tokyo, Japan and of 81, Neribei-cho, Kanda, Chiyoda-ku, Tokyo, Japan, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed to be particularly described in and by the following statement:—

The present invention relates to moulded articles, particularly cups, tins, bottles, boxes, toys, buckets, etc., of a thermoplastic resin as well as apparatus for moulding such articles.

In recent years, plastics articles have been taking the place of articles made of paper, glass, ceramics, metal and other materials. These plastics articles, however, are still not completely satisfactory as regards price, properties, dimensions, shape, appearance, moulding method and so forth. For instance in vacuum moulding and drawing of a sheet, material and blowing of two clamped sheets, the yield of the products with respect to the raw material sheets is very low with a great quantity of waste scraps of sheets. Finish cuts are required to a considerably large number of portions of the processed article. Many flows and scratches result. It is necessary to use raw material sheets of excessive thickness because the portions of the sheets to be expanded to the greatest extent determine the required standard, and it is generally difficult to obtain uniform thickness of various portions of the article and to provide adjuncts to desired portions of the article which have desired wall thicknesses. In extrusion blow moulding, as the parison, a tubular resin extruded from an extruder, is clamped and sheared by the sectional mould, the sheared edge of the article has a number of large mould flashes, many flaws and scratches also result, and it is generally difficult to obtain uniform thickness of each portion of the article and to provide adjuncts to desired portion of the article which have desired wall thicknesses. In injection moulding, a resin having a low fluidity can not be used as the raw material, and it is difficult to mould mouldings having thin wall portions and mouldings requiring flow of the moulding material over long distances. Also in injection moulding, the mould costs are high, hollow articles such as bottles, etc., can not be directly obtained, re-use of the runner material is necessary, and flaws and scratches resulting from gates, projecting pins, mating faces of the mould and so forth remain in the final products. In compression as well as transfer moulding, where thermoplastic synthetic resin is used, it is necessary to cool the mould to a temperature below the heat distortion temperature of the resin before taking the moulded article out of the mould, so that this method is not profitable in practice. Moreover, these techniques are not suitable for producing hollow articles such as bottles, etc.

Further, in what is called powder moulding where powdered synthetic resin such as polyethylene is filled in a mould of a desired contour followed by externally heating the mould to form a sintered layer over the inner surfaces of the mould and, after removing excess material remaining in a powdery state, the mould is cooled to obtain a moulding having a configuration corresponding to that of the inner surfaces of the mould, or in what is called liquefied moulding where liquefied moulding material prepared by dissolving a synthetic resin in an organic solvent is moulded into desired articles, uniformity of the thickness of the walls of the

produced articles can be achieved. In these methods, however, it is difficult to provide a desired degree of wall thickness and a desired adjunct at a given place of the article and to provide exact control of the inner and outer dimensinos of the article in the vicinity of the mouth thereof. In addition, powder moulding is unsuitable for the manufacture of articles having small volume and small wall thickness, and it often results in the loss of sintered resin. On the other hand, the liquefied moulding method has various problems such as complexities involved in the after-treatment of the organic solvent. All of the disadvantages discussed hereinabove are particularly critical for articles having small volume and small wall thickness.

According to the invention there is provided an apparatus for moulding thermoplastic resin articles comprising a rotary shaft rotatably mounted on a stationary shaft provided with an air conduit, a plurality of male moulds, each being secured to the rotary shaft and having a heating means, air-blow valves respectively provided in said male moulds and arranged for bringing preform mouldings on said male moulds successively into communication with the air conduit for blow moulding said preform mouldings, a raw material feed means for attaching raw material onto the top centre of each male mould as it passes through a feed station, two lining sleeves each of which has a cavity contoured such that a preform moulding may be compressively formed between any of the male moulds and the lining sleeve, a female mould for supporting each lining sleeve during compressive formation of a preform moulding, a cooling mould for cooling each lining sleeve and a preform moulding contained therein, each of the female and cooling moulds having a cavity contoured so as to engage the outer surface of each lining sleeve, and a product blow mould having a cavity contoured such that it can be engaged with any of the male moulds for transformation of a preform moulding into a product article having desired dimensions, by blow moulding.

An embodiment of the invention and these modifications thereof are described below, by way of example only, with reference to the accompanying drawings, in which:

Figure 1 is a sectional elevation of an apparatus for moulding thermoplastic resin articles, which apparatus has several features in common with the present invention;

Figures 2 and 3 are sectional elevations of an embodiment of the present invention showing different stages of a working cycle;

Figures 4, 5 and 6 are sectional elevations of parts of modified embodiments of the invention; and

Figures 7 and 8 are respectively transverse and vertical sections illustrating apparatus for the manufacture of a handle-carrying square-sectioned bottle in accordance with the invention.

The apparatus shown in Figure 1 is for manufacturing a cup and is described below to facilitate explanation of the advantages of the present invention.

In Figure 1, the reference numeral 7 designates a central stationary shaft, on which is mounted a rotary shaft 8. In the embodiment, under the shaft 8 is a compression moulding station (preform moulding station), over the shaft is a blow moulding station, at the left of the shaft is a temperature control (cooling) station, and at the right of the shaft is a temperature control (heating) station. On the shaft 8 is provided four male moulds 1, each having heating equipment, such that each of the moulds comes to each of the stations after moving one-fourth rotation. The stationary shaft 7 is provided with an air conduit 15 which is open to only the upper blow moulding station. The male mould 1 is provided with an air-blow valve 2 which is in a closed state when the male mould is in the compression moulding station. In operation, a predetermined quantity of resin designated by *a* is loaded in a female mould 3 located at a position indicated in Fig. 1 by a chain line. The female mould 3 is then pushed upward together with a mounting table by means of an assembly of piston, ram, togglecrank, or wedge to the position indicated by a solid line to compress the raw material resin *a* filling the gap between the engaged male and female moulds 1 and 3 so as to form a preform moulding *b*. After the formation of the preform moulding *b*, the female mould 3 together with the mounting table is lowered by means of the assembly of piston, ram, togglecrank, or wedge, back to the original position indicated by the chain line, while the preform moulding *b* is caused to remain on the male mould. The preform moulding *b* is allowed to remain on the male mould 1 by preventing it from sticking to the female mould 3 by suitably selecting difference in temperature between male and female moulds, kinds of mould lubricants, difference in effects of different mould lubricants for male and female moulds, difference in concentrations of the mould lubricant for male and female moulds. It is to be understood that the operating conditions such as maintenance of the male and female moulds 1 and 3 at moulding temperature or fusion temperature of the resin by heating means, metal-plating of the mould surfaces in contact with the resin, use of the raw material resin *a* in powdered granular or part-moulded form, preheating of the resin and so forth are selected depending upon the properties of the resin, moulding conditions,

shape of the mouldings, wall thickness of the mouldings and other factors as in conventional compression and transfer moulding. The male and female moulds are designed such that the gap defined by them when they are in compression engagement can provide a preform moulding *b* preformed to a shape which is similar to the shape of the final product and as simple as possible, permits moulding resin to be readily moulded or to be readily caused to melt and flow, prevents fluctuation of the wall thickness of the article, and allows predetermined distribution of the wall thickness during a subsequent blow moulding operation which is described hereinafter in detail.

The preform moulding *b* thus formed and remaining on the male mould 1 is then brought by one-fourth clockwise rotation of the rotary shaft 8 to the temperature control station where the prototype moulding is subjected to temperature control to the temperature most suitable for the blowing operation. The temperature control may be achieved by internally cooling the male mould 1 with cooling means provided within the male mould 1, or alternatively it may be achieved by externally cooling the male mould 1, for instance by covering the moulding *b* with a cooling mould having the same size as that of the female mould 3 and effecting cooling by directing cooling air or cooling water on to the cooling mould, or by immersing the cooling mould directly in water. The temperature control as described above may be dispensed with depending upon the resin and the wall thickness of the moulding, and the preform moulding may then be directly transferred from the compression moulding station to the blow moulding station but, in most cases, blow moulding will take place at a lower temperature than compression moulding. When the temperature of the preform moulding *b* in the temperature control station has been controlled to a temperature suitable for the subsequent blow moulding, the male mould 1 is transferred to the blow moulding station by one-fourth rotation of the rotary shaft 8. Here, a product blow mould 4 maintained at room temperature (and sometimes having a cooling means), descends and engages the male mould 1 to clamp the preform mouldings hermetically between the male mould 1 and the product blow mould 4 by means of a packing 6 provided to seal the product blow mould 4. Alternatively, the use of packing 6 may be dispensed with and similar effects may be attained by bringing the mouth of the product blow mould 4 in close contact with the corresponding mouth portion of the preform moulding *b*, as indicated by the reference character *g* in Figs. 4 and 5. Upon one-fourth rotation of the shaft 8 from the temperature control station to the blow moulding station, the cam action of the stationary shaft 7 forces air-guide pin 5 upward so as to bring the airblow valve 2 of the male mould 1 into communication alignment with an air-inlet passage 15 formed in the stationary shaft 7. By blowing air under a controlled pressure and at a controlled temperature through the open valve 2, the preform moulding *b* is expanded and progressively separated from the top to the bottom of the male mould 1 so as to transfer the moulding *b* to the inner surfaces of the product blow mould 4 which is finished to the dimensions of the product article, the separation of the preform moulding *b* from the male mould 1 being effected progressively from the top to the bottom of the male mould 1. At this time the air existing between the product blow mould 4 and the preform moulding *b* is forced out of the mould 1 through air discharge conduits *f* by the pressure due to the expansion of the preform moulding *b* or is pumped out of the mould by evacuating means. In this way, the preform moulding is transformed into the final product *c*.

When the transfer of the moulded resin from the male mould 1 to the product blow mould 4 has been completed, the product blow mould 4 carrying the product *c* is separated from the male mould 1 and moved upward. The product *c* is then taken out of the product blow mould 4 and the mouth portion which has been in contact with the packing 6 is then machined away and mould flashes formed at the time of moulding are cut off the blown article, thus obtaining a complete product, which is then transmitted to the subsequent process stations for printing, packaging, filling, etc.

After the product blow mould 4 carrying the product *c* has been separated from the male mould 1, the male mould 1 is transferred to the right-hand temperature control station by one-fourth rotation of the rotary shaft 8. By this rotation of the rotary shaft 8, the air-blow valve 2 is closed. The male mould 1 is then heated to a moulding temperature suitable for the resin to melt and flow before being transferred to the compression moulding station. Where no heating is required, the male mould 1 is directly transferred from the blow moulding station to the compression moulding station. In the above described mode, the simultaneous working at the compression moulding station, cooling station, blow moulding station and heating station, or the simultaneous working at the compression moulding station and blow moulding station, enables successive production of the articles by intermittent movement of each of four male moulds 1 by the successive one-fourth rotations of the rotary shaft 8.

If an adjunct *h* such as a knob or a handle

is necessary as shown in Figures 7 and 8 the female mould is made as a sectional mould. This sectional mould is held open during its vertical movement and is only closed when it is in a position to engage the male mould. The resin may be charged in the gap between the male and female moulds in the manner as described before so that clamping together of halves of the sectional female mould causes the formation of the preform moulding *b*. Adjunct forming cavities are formed in the split surfaces of the female mould, so that the adjuncts may be formed as integral parts of the preform moulding *b* at the time of preform moulding. The blow mould 4 at the blow moulding station is also a sectional mould. This sectional mould has an enlarged adjunct cavity to allow clearance for expansion of the moulding *b* during blow moulding. The blow mould 4 is advanced in the open state to the male mould 1 and closed thereon, and then blow moulding takes place as described above.

According to the method described in the foregoing, almost any resin may be used, the size, shape and wall thickness may be selected as desired, desired adjuncts may be provided at given places of the article, and different wall thicknesses may be desirably selected for different portions of the article by specifying the dimensional relation between the male mould 1 and the product blow mould 4.

Also, the above method affords precise finish of the mouth of the moulded article, results in extremely few flaws and scratches on the finished surfaces after cutting off the mould flash from the moulded article and also in reduced quantities of raw material loss, requires cheap moulds, small sized equipment and permits simple and rapid operation which are easy to automate. In this method, however, immediately after the formation of the preform moulding by compression and plastic flow of the raw material resin by means of the male and female moulds, the female mould is separated from the male mould with the preform moulding remaining on the male mould. This means that the separation of the female mould is made when it is at a high temperature, namely at the moulding temperature and the male mould is kept also at the moulding temperature. As a result, depending upon the resin used the heating of the resin results in loss of transparency, rough surfaces and disappearance of lustre of the product. To avoid these phenomena, either both the female and male moulds or only the female mould may be cooled. As the moulds have a large wall thickness to withstand the moulding pressure, cooling and temperature recovery of the mould require much heat and time, so that the temperature control can not be quickly made, thus extremely reduring the productivity.

According to the present invention, the above mentioned disadvantages are obviated by using a lining sleeve having about 1 to 5 mm in wall thickness and having inner surface similar in shape to the outer configuration of the male mould and capable of forming the preform moulding and having an outer surface so dimensioned as to fit neatly into a removable female compression mould. During compression moulding, this sleeve serves as the female mould and during removal of the actual female compression mould it remains on the formed preform moulding and clamps the moulding *b* between itself and the male mould. After separation of the female mould and male mould carrying the preform moulding, the male mould is carried to the cooling station where the sleeve is cooled rapidly by directing cooling water, air and the like onto the sleeve, immersing the sleeve in water, or engaging a closely fitting cooled metal mould on the outside of the sleeve.

The improved method of moulding using the cooling sleeve for the female mould is now described in conjunction with one embodiment of apparatus for moulding a hollow bottle.

As shown in Figs. 2 and 3, a rotary shaft 8 is mounted on the central stationary shaft 7. Below the shaft 8 is a raw material feed station, at the left of the shaft is a compression moulding station, above the shaft is a cooling station and at the right of the shaft is a blow moulding station. As in the previous embodiment, the rotary shaft 8 is rotatably mounted on the stationary shaft 7 and the rotary shaft carries four male moulds 1 each having a heating means. Each male mould 1 executes one-fourth rotation for respective operations, and while the rotary shaft 8 is in rotation, a sleeve exchanger 10 moves a sleeve from the cooling station to the compression moulding station. The stationary shaft 7 is provided with an air-inlet passage 15 open only to the male mould 1 in the right-hand blow moulding station. As shown in Figs. 2 and 3, in each of the male moulds 1 is provided an air blow valve 2 which is closed when the associated male mould 1 is in the raw material feed station. In the raw material feed station, means previously supplied with a predetermined quantity of raw material from a raw material resin supply such as a hopper is pressed upward to be closely fitted on the male mould 1 for the attachment of raw material resin *a* on the central top of the male mould 1 as shown in Fig. 2. The resin supplied from the raw material resin supply is preheated to a temperature 10 to 50°C lower than the moulding temperature, while the raw material feed means 13 is maintained at a

temperature 10 to 20°C higher than the resin temperature and over 5°C lower than the temperature of the male mould 1. The difference in temperature between the male mould 1 and the feed means 13, the presence or absence, concentration and kinds of mould lubricants are suitably selected to ensure attachment of the raw material resin on the central top of the male mould 1.

When the raw material resin *a* has thus been attached to the central top of the male mould 1, the feed means 13 is lowered back to the original position. Afterwards, the male mould 1 carrying the raw material resin *a* is moved clockwise one-fourth rotation about the shaft 7 to the compression moulding station. Concurrently with this movement, the sleeve exchanger 10 carrying a sleeve 9 proceeds down from the cooling station to a point on the path of travel of the female mould and is retained in that positon for engagement of the sleeve 9 with the female mould 3. The female mould 3 is moved together with its mould mounting table to the position occupied by the sleeve 9 under the action of piston, ram, togglecrank, or wedge, to engage the sleeve 9, and remains in that position till the sleeve 9 is heated to the required temperature. Upon heating of the sleeve to the required temperature, the sleeve exchanger 10 is separated from the sleeve 9 and returned to the initial position shown in Fig. 3. Thereafter, the female mould 3 in engagement with the sleeve 9 is moved toward the male mould 1 until in engagement therewith. The raw material resin *a* attached on the centre top of the male mould 1 is consequently heated and compressed and subjected to forced flow in the gap between the male mould 1 and the sleeve 9 and formed into a preform moulding *b*. Thereafter, the female mould 3 together with the mould mounting table is returned to its initial position as shown in Fig. 2 by means of piston, ram, togglecrank, or wedge, while the sleeve 9 remains on the male mould 1 around the preform moulding *b*. As before, the operating conditions such as maintenance of the male and female moulds 1 and 3 at moulding temperature of the resin by heating means, metal-plating of the mould surfaces to be brought in contact with the resin, compression degree of the raw material resin *a*; and the state and temperature of the raw material resin *a* before compression and so forth are selected in dependence upon the properties of the resin, moulding conditions, shape and wall thickness of the mouldings as in the case of conventional compression moulding and transfer moulding. The male mould and female mould (including a lining sleeve) are, as before, designed such that the gap defined by them when they are in compression engagement can provide a preform moulding *b* which is preformed to a shape which is as similar to the shape of the final product and as simple as possible, permits moulding resin to be readily moulded or to be readily caused to melt and flow, prevents fluctuation of the wall thickness of the article, and allows predetermined distribution of the wall thickness during blow moulding, as described hereinafter in detail. The preform moulding *b* thus formed is transferred to the cooling station by one-fourth rotation of the rotary shaft 8 while being clamped between the male mould 1 and the sleeve 9. When the male mould 1 comes to the cooling station a cooling mould 11 is lowered together with its mould mounting table under the action of piston, ram, togglecrank, or wedge down to engagement with the sleeve 9 on the male mould 1, as shown in Fig. 3, to achieve cooling of the preform moulding *b*. The cooling mould 11 may be a metal mould provided with a cooling water circulating means, a mould having a mouth portion designed to closely fit the mouth of the sleeve, and may be provided with means to direct cooling water or air to the sleeve, or it may be any other suitable mould depending upon the physical properties of the resin. When the preform moulding *b* in the cooling station has been cooled down from the higher temperature at which compression moulding takes place to a temperature suitable for the blow moulding operation, the cooling mould 11 together with the sleeve 9 is separated from the male mould 1 with the preform moulding *b* remaining thereon. The sleeve 9 is moved along with the cooling mould up to a point of intersection with the path of travel of the sleeve exchanger 10, at which point it is temporarily brought to a halt. Upon halting the cooling mould 11 at the position shown in dashed outline in Fig. 2, the sleeve exchanger 10 is driven in the clockwise direction from the position shown in Fig. 3 to engage the sleeve 9 carried by the cooling mould 11. Upon engagement of the sleeve exchanger 10 with the sleeve 9, the cooling mould is returned to its non-working position shown in Fig. 2. When the cooling mould has been retracted, the sleeve exchanger 10 together with the sleeve 9 is now moved back to the point of intersection with the path of travel of the female mould 3 for subsequent engagement of the sleeve 9 with the female mould 3, and finally returned to the initial position indicated in Fig. 3 to complete the cycle of operation.

Subsequent to the cooling of the preform moulding *b* to a temperature suitable for the blow moulding operation, the male mould 1 is transferred to the blow moulding station by one-fourth rotation of the rotary shaft 8.

In the blow moulding station, a blow mould 4 which has a cooling means and

whose inner configuration is dimensioned to meet the outer configuration of the product article are driven together with the mould mounting table by means of piston, ram, togglecrank, or wedge, into engagement with the male mould 1. The air-tight seal between the male mould 1 and the blow mould 4 may be ensured either by closely fitting the mouth portion of the blow mould 4 directly on the mouth portion of the preform moulding *b* surrounding the male mould 1 as shown in Figs. 3 to 5, or by using a packing 6 as shown in Fig. 6. Upon arrival of the male mould 1 at the blow moulding station, the cam action of the stationary shaft 7 forces an air-guide pin 5 upward so as to bring the air-blow valve 2 of the male mould 1 into communication alignment with an air-inlet passage 15 formed in the stationary shaft 7. By blowing air under a controlled pressure and at a controlled temperature through the air blow valve 2, the preform moulding *b* is expanded and transferred to the inner surfaces of the product blow mould 4, the separation of the preform moulding *b* from the male mould 1 being effected progressively from the top to the bottom of the male mould 1. As in the previous embodiment, air existing between the product blow mould 4 and the preform moulding *b* is forced out of the mould 1 through air discharge conduits *f* during expansion of the preform moulding *b*, or is pumped out of the mould by evacuating means. In this way, the preform moulding *b* is transformed into the final product having desired shape and dimensions.

When the transfer of the preform moulding from the male mould 1 to the product blow mould 4 has thus been completed, the product blow mould 4 carrying the product *c* is separated from the male mould 1 and returned to the position indicated in Fig. 2, while the male mould 1 is again transferred to the raw material feed station by the one-fourth rotation of the rotary shaft 8.

Successive operations, as described in the foregoing are repeated time and again, thereby continually producing product articles *c*. Upon returning of the product blow mould 4 to the position indicated in Fig. 2, a product take-up member 12 is driven upward up to a point along the path of travel of the product blow mould 4 and is stopped in that position. Then the product blow mould 4 together with its mould mounting table is slightly moved by piston, ram, togglecrank, or wedge, up to a position just in front of the product take-up member 12 so that the product *c* may be received by the product take-up member 12. When the product *c* has been received by the product take-up member 12, the product blow mould 4 is returned to the initial position. If the blow mould 4 is a sectional mould it is also separated into two halves during this operation. The product article 2 transferred to the product take-up member 12 is moved downward to the lowered position indicated in Figs. 2 and 3 where mould flashes formed during formation of the preform moulding on the mouth portion thereof and portions in contact with the packing 6 are cut off by a cutting tool 14 such as a cutting blade. Then the finished article *c* is taken out of the product take-up member 12, by such an operation as blowing it out and is further transfered by means of, for instance, a conveyor to the following process stations for printing, packaging, filling, etc.

The above described various operations such as feeding the raw material resin, compression moulding, cooling, blowing, sleeve exchange, and taking up of the product article are all carried out at the same time as is shown in Figs. 2 and 3. To maintain continual production of the mouldings, therefore, it is required to have one female mould 3, four male moulds 4, one cooling mould 11, two sleeves 9, one product blow mould 4, one feed apparatus 13, one sleeve exchanger 10 and one product take-up member 12 to ensure continual production of the articles, in keeping pace with intermittent successive one-fourth rotation of the rotary shaft 8.

When moulding large-size articles such as a container of a large volume capacity, or a bath tub by the use of the usual compression moulding press, the formation of the preform mouldings may be readily and rapidly effected by using lining sleeves for both the male and female moulds.

Using a moulding press comprising heated male and female moulds and a cooling press comprising cooled male and female moulds, and fitting lining sleeves in male and female moulds of the moulding press, the raw material resin is compressed betweeen both sleeves and the moulded resin is taken out together with both sleeves and placed in the cooling press for cooling. By using two moulding presses for engagement with alternate male moulds the efficiency may be further increased.

In the blowing operation in accordance with the invention, the mutual relationship between the preform moulding *b* and the product article *c* is very important. For instance the thickness of portions of the preform moulding indicated at *d′* and *e′* are chosen by allowing for elongation of the raw material due to expansion so that portions indicated at *d* in Figs. 1, 4, 5, 6 and 7 and portions indicated at *d* and *e* in Fig. 6 may respectively have required wall thickness. To ensure correct transformation of portions *d′* and *e′* into portions *d* and *e* in the figure, it is necessary that the preform moulding *b* is preformed to a shape which is readily trans-

formed by blow moulding into the product article. Further, it is necessary to consider the facts that the preform moulding does not literally expand simultaneously in all directions but is rather displaced incrementally to positions more distant from the air-blow orifices, and that the greater this distance the greater is the displacement of the resin. Further, to ensure correct transformation of portions *d'* and *e'* into portions *d* and *e* it is necessary to suitably control the displacement of the resin by taking into consideration such operational factors as properties and temperature of the resin, temperature and pressure of the blowing air, quantity of the mould lubricants, difference in effects due to different kinds of mould lubricants, temperature of the product blow mould 4, position and size of the air discharge conduits *f*, degree of vacuum in the case of vacuum drawing. There exists a constant relationship between these factors. Such relationship can be previously taken into account to avoid errors or to reduce these errors to extremely small dimensional errors which will not present any problem in view of commerciability. In moulding hollow articles such as bottles and toys the blow mould used is a sectional mould while in moulding open cavity articles such as glasses the blow mould is a unitary mould, and when a sectional mould is used it is brought in an open state up to the male mould before it is closed on the male mould, which is the same as in usual blow moulding.

The exact finish of the mouth portions *g* of the moulding to the specified outer and inner dimensions may be ensured by the arrangement shown in Figs. 4 and 5 where the mouth portion of the male mould 1 and of the product blow mould 4 is dimensioned respectively to the inner and outer dimensions of the product article and where without using packing 6 the mouth portion of the product blow mould 4 is directly closely fitted to the mouth of the preform moulding for subsequent blowing and other operations as described in the foregoing. The air-blow valve 2 may be made of any desired structure besides those valves shown in Figs. 1, 2, 3 and 6 which protrude from the male mould 1. For instance, a cross valve shown in Figs. 4 and 5 may be used which has its orifices open at both sides of the male mould 1.

The resin to be used in accordance with this invention may include thermoplastic resins. For instance, it may be a vinyl polymer such as polyvinyl chloride, polyvinyl acetate, polyvinylidene chloride, polystyrene, acrylic resin, a polyolefin such as high density, medium density and low density polyethylene, polypropylene, a polyamide such as nylon, an acetal resin, a diene polymer such as acrylonitrile-butadiene-styrene copolymer, or a polyester resin such as polycarbonate. Further it may be a polymer blend as well as a homo-polymer or copolymer. An addition of small quantity of rubber such as synthetic rubber, for instance NBR (i.e. Nitrile-Butadiene rubber) and SBR, and natural rubber to the above polymer can increase the impact resistance of the moulding at low temperatures.

As has been described in the foregoing according to the process of this invention, unlike conventional blow moulding where the extruded tubular resin or parison is blown up, on injection moulding where the raw material is injected to the mould, or compression moulding where the raw material is compressed by the mould, the raw material resin is first formed into a preform moulding having an excellent mouldability and excellent melting and flowing properties and having a configuration which is readily blow-moulded into the final product. This preform moulding is subsequently blown into the product article, so that it is possible to have desired wall thicknesses for required portions of the final product to provide an adjunct at a required place, and to ensure exact dimensions of the mouth and bottom portions of the moulded article. Also, according to the invention there is no repeated heating and cooling the same mould, no introducing hot resin into a cold mould under pressure as in the conventional moulding processes. The heating mould, the cooling mould and the product blow mould are all separately provided. The heating mould forms the preform moulding, the cooling mould cools the preform moulding, and the product blow mould provides a housing for blowing the preform moulding into the product article, and these operations take place in a continuously successive order, so that extremely good operational efficiency is obtained. Also, according to the invention loss of raw material is small since mould flashes are produced only on top of the mouth portion of the preform moulding and the thickness of these flashes is about 0.1 to 0.3 mm, which is very small as compared to many large mould flashes generated at the cut end of the parison in the prior art moulding of hollow articles, at portions along a line along which both halves of the usual sectional mould meet, and at portions in contact with runners and gates of the conventional injection mould. Also, the metal mould according to the invention is very cheap and easy to operate. Further, as the forming and finishing of the product are continually and automatically effected, and the manufacture is very economical.

Further, according to the invention, it is possible to produce articles of tubular shape, or hollow articles such as bottles, etc. to

control size and wall thickness of the article to be produced such as cup, tin, box, bucket, bottle, toy and so forth. Furthermore, the product is free from such undesirable finish surfaces as cut ends of the parison used in the production of hollow mouldings and the surfaces which have been in contact with gates of the mould and extruding pins, with the only flaws being almost unnoticeable streaks which occur at portions initially in contact with the air-blow valve 2 and at portions along the division line between both halves of a sectional mould. Moreover, the internal deformation of the article is extremely small. Making use of a lining sleeve in accordance with this invention permits obtaining excellent cooling effect, quick temperature control, and product articles having beautiful appearance due to increased lustre, transparency and smoothness. Also, the ability to mould articles having extremely thin walls in accordance with this invention is particularly useful for the production of containers for particular uses, such as containers for milk, yogurt, and fruit juice. Further, as the moulding apparatus in accordance with this invention is of very simple construction and can be directly combined with the loading apparatus for milk, yogurt, fruit juice and the like, the containers produced by the apparatus in accordance with this invention can be directly supplied to the loading apparatus, without transportation and sterilization of these containers for the loading of the content.

WHAT WE CLAIM IS:

1. An apparatus for moulding thermoplastic resin articles comprising a rotary shaft rotatably mounted on a stationary shaft provided with an air conduit, a plurality of male moulds, each being secured to the rotary shaft and having a heating means, air-blow valves respectively provided in said male moulds and arranged for bringing preform mouldings on said male moulds successively into communication with the air conduit for blow moulding said preform mouldings, a raw material feed means for attaching raw material onto the top centre of each male mould as it passes through a feed station, two lining sleeves each of which has a cavity contoured such that a preform moulding may be compressively formed between any of the male moulds and the lining sleeve, a female mould for supporting each lining sleeve during compressive formation of a preform moulding, a cooling mould for cooling each lining sleeve and a preform moulding contained therein, each of the female and cooling moulds having a cavity contoured so as to engage the outer surface of each lining sleeve, and a product blow mould having a cavity contoured such that it can be engaged with any of the male moulds for transformation of a preform moulding into a product article having desired dimensions, by blow moulding.

2. An apparatus for producing thermoplastic resin articles substantially as herein described with reference to Figures 2 and 3 of the accompanying drawings, with or without the modification substantially as herein described with reference to Figure 4, Figure 5 or Figure 6, and with or without the modification substantially as herein described with reference to Figures 7 and 8.

3. A thermoplastic resin article made with apparatus according to claim 1 or claim 2.

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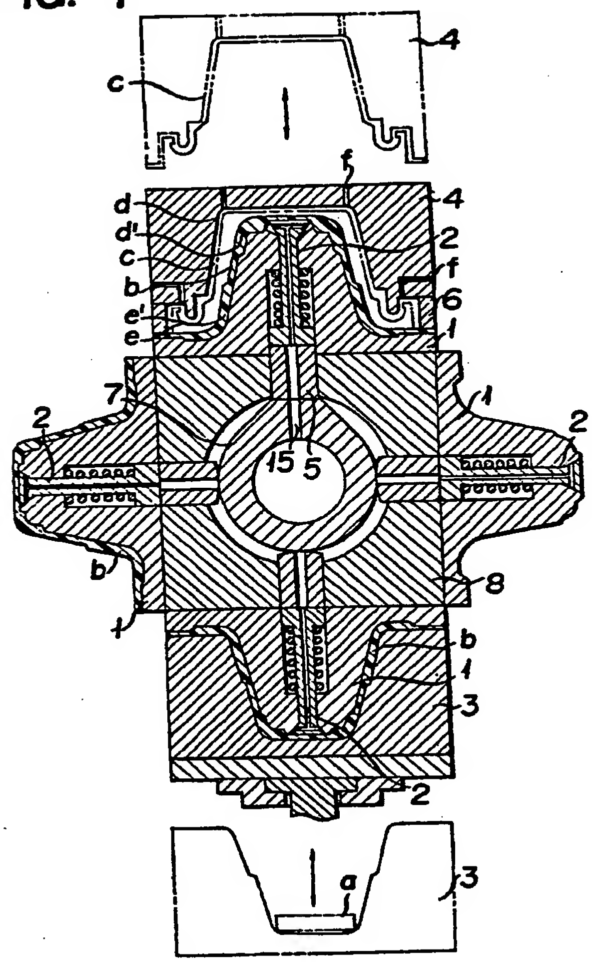
FIG. 1



1166893 COMPLETE SPECIFICATION

4 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 2

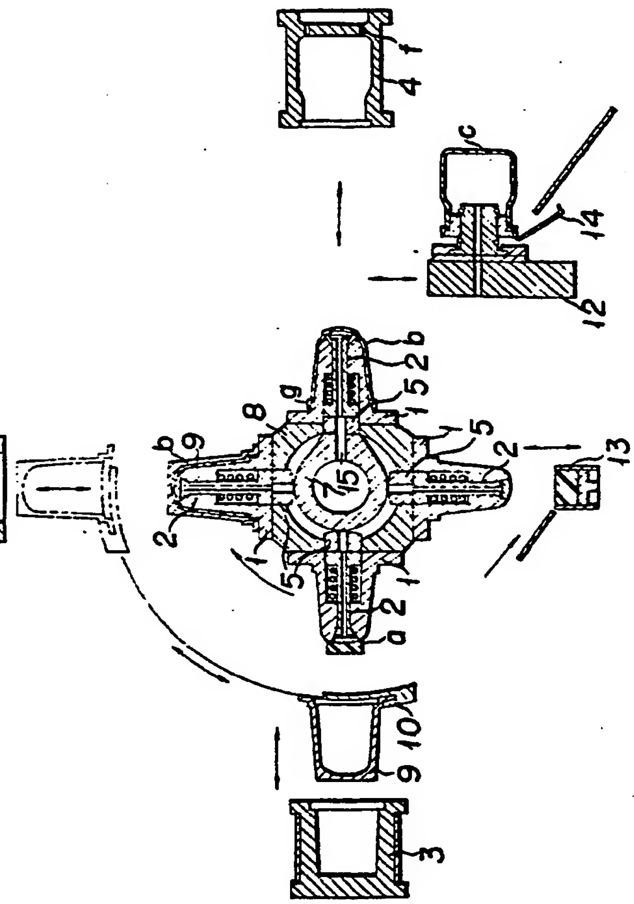


FIG. 2

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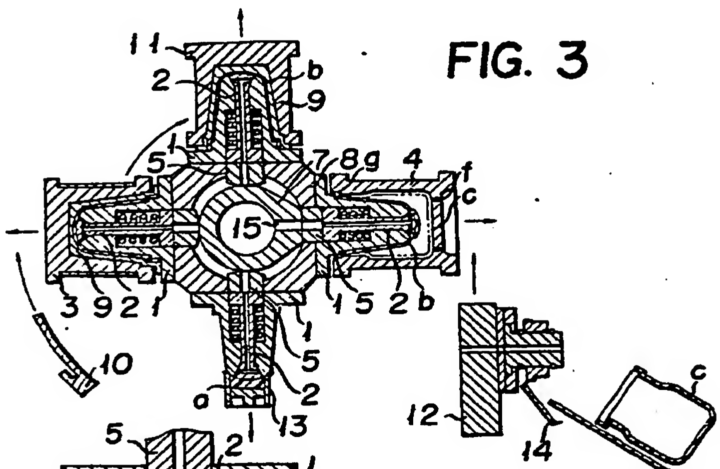

FIG. 3

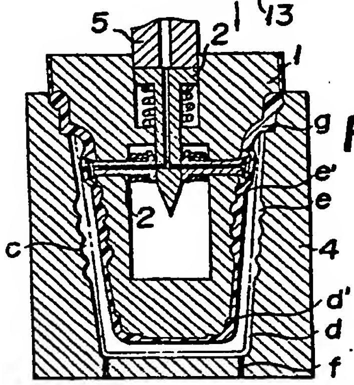

FIG. 4

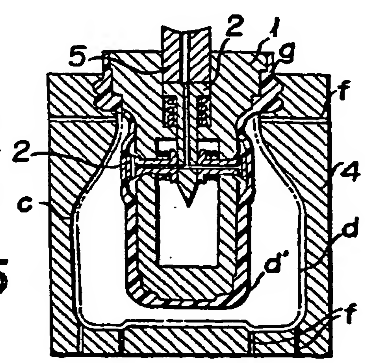

FIG. 5

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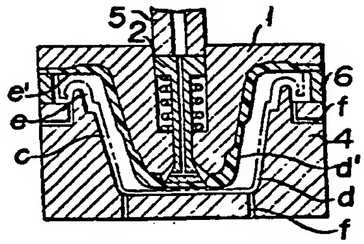
FIG. 6



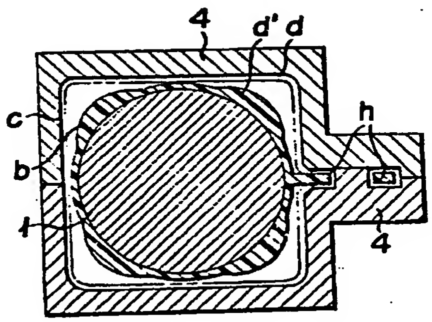


FIG. 7

FIG. 8